Electrostatics:
Potential Energy and Electric Potential (Voltage)

Energy is related to work.
Difference in potential energy = work done moving from one point to another.

Voltage or Potential is energy per unit charge.
E_e is electrostatic energy
E is electric field strength $E=F_e/q$
V is potential $V=E_e/q$

Gravity	Electrostatics
Force between masses $F_g=GMm/r^2 = mg$ Use GMm/r^2 where g is not constant Use mg if g is constant	Force between charges $F_e=kQq/r^2 = Eq$ Use kQq/r^2 for point charges Eq for E is constant
$E_g=-GMm/r$ Relative to Eg=0 at r=infinity = mgh Relative to any point	$E_e=kQq/r$ (not negative because the force is repulsive) relative to 0 at infinty $\Delta E_e=-qEd$ energy moving a charge q in the direction of

	an electric field E through a displacement d (negative because the field is pulling the positive charge in the direction of the field)
	$V = E_e/q = kQ/r$ $\Delta V = -Ed$

Eg. 1. An electron jumps from an orbital a distance 1.0×10^{-10}m to 5.0×10^{-11}m from a proton.

a) What is the electrostatic potential energy of the electron in each position relative to 0 at infinity?
b) What is the voltage at each orbital?
c) What is the potential difference between the outer and inner orbital?
d) What is the energy of the released photon? (energy difference)

2. Two parallel plates are 0.50 cm apart and connected to a 9.0V battery.

a) What is the electric field strength between the plates?
b) How much energy is required to move an electron from the negative plate to the positive

plate?

c) How much work is done moving a proton 0.20 cm towards the positive plate?

e= 1.602 x 10^{-19} C (magnitude of the charge of proton or electron)

1a) E_e= kQq/r = 9.0 x 10^9Nm^2/C^2 (1.6x10^{-19}C) (-1.6x10^{-19}C) / 1.0 x 10^{-10}m

E_e=-2.3 x 10^{-18} J and -4.6 x 10^{-18} J

b) V=E_e/q =-2.3x10^{-18}J/-1.6x10^{-19}C = 14 V
A volt is the unit of electric potential V=J/C

And 28V

c) Difference = Vf - Vi = 28V-14V = 14V

d) Energy = 14eV = 2.3 x 10^{-18}J

eV is a unit of energy = 1eV = 1.6 x 10^{-19}J (keeners E=hf f=2.3x10^{-18}J/6.6x10^{-34}Js =3.5 x 10^{15}Hz wavelenth = v/f = 3.0 x 10^8m/s/3.5 x 10^{15}Hz = 8.6 x 10^{-8}m ultraviolet light)

2.

Electrostatics
Electrostatic Potential Energy, E_e
Electrostatic Potential (Voltage), V

Energy is the ability to do work. We can derive our energy equation from
W=Fd or the area under an F - d graph, just like gravity.

Gravity	Electrostatics
Pull between all masses, m or M in kg	Push or pull between all charges, q or Q in C
$F_g = GMm/r^2$ between any 2 masses	$F_e = kQq/r^2$ between any 2 charges
$F_g = mg$ if g is uniform and known	$F_e = Eq$ if the electric field strength, E, is given or is uniform (parallel plates)
Einstein curvature of space time	Feynman - transfer of bundles of energy
$E_g = mgh$ if g is uniform	$\Delta E_e = -qEd$ where q is the charge, E is electric field and d is the displacement the charge moves in the direction of the field.
$E_g = -GMm/r$	$E_e = kQq/r$ (not negative

The work to bring mass m from infinity to r	because force is repulsive) The work to bring q from infinity to r
	Define electric potential (Voltage) $V = E_e/q$
	Potential difference $\Delta V=-Ed$ (if d is in the direction of the field) $V=kQ/r$

Eg. A 1.0 μC charge is 0.50 m from a 2.0μC charge.

a) What is the electrostatic potential energy of the 1.0 μC charge?

$E_e=kQq/r = 9.0 \times 10^9 (2.0 \times 10^{-6}C)(1.0 \times 10^{-6}C) / 0.50 m = 0.036 J$ relative to 0 at infinity

b) What is the potential at the 1.0 μC charge?

$V= E_e/q = 0.036 J/ 1.0 \times 10^{-6}C$

$= 3.6 \times 10^{-8}V$ (unit is volts, V= J/C)

c) How much work is done if the 1.0 μC charge is moved 0.20 m closer?

W= Fd if F is constant

$W=\Delta E_e = E_{ef}-E_{ei} = kQq (1/rf - 1/ri)$

$9 \times 10^9\ Nm^2/C^2\ (2.0 \times 10^{-6}C)(1.0 \times 10^{-6}C)$
$(1/0.30m - 1/0.50m) = 0.024J$

2. Two parallel plates are 0.25 m apart and have a 20.0 V potential difference. Determine

a) The electric field between the plates

b) The kinetic energy gained by an electron moving from the negative plate to the positive plate.

a) $\Delta V = -Ed$
$E = 20.0V/0.25m = 80.0\ N/C$

Direction of the electric field, E, is from the high voltage plate (postive plate) to the low voltage plate(negative plate)

b) $\Delta E_e = \Delta E_k = Vq = 20.0V \times 1.6 \times 10^{-19}C$
$= 3.2 \times 10^{-18}J$
Or 20.0 eV   eV is a unit of energy, the electron volt. $1eV = 1.6 \times 10^{-19}J$

Eg. 1. An electron jumps from an orbital a distance $1.0 \times 10^{-10}m$ to $5.0 \times 10^{-11}m$ from a proton.

a) What is the electrostatic potential energy of the electron in each position relative to 0 at

infinity?

b) What is the voltage at each orbital due to the proton?

c) What is the potential difference between the outer and inner orbital?

d) What is the energy of the released photon? (energy difference) in eV and in J

2. Two parallel plates are 0.50 cm apart and connected to a 9.0V battery.

a) What is the electric field strength between the plates?

b) How much energy is required to move an electron from the negative plate to the positive plate? In eV and in J.

c) How much work is done moving a proton 0.20 cm towards the positive plate?

e= 1.602 x 10^{-19} C (magnitude of the charge of proton or electron)